The air-electrode of the fuel cell 1 is connected to an air piping 7 for supplying outside air (dry air Ad) which is inhaled from an intake opening 11 and serving as the oxidizer, to an oxidizer inlet opening 12; and an out-air piping 8 for discharging the out-gas (wet out-air OAw) which is discharged from the oxidizer outlet opening 13, to the exhaust opening 14.

In the air piping 7 from upstream side to downstream side of the flow of dry air Ad (that is, from the intake opening 11 to the fuel cell 1), there are provided a supercharger 2, a first shutoff valve 41 and a humidifier 3 in the stated order.

In the out-air piping 8 from upstream side to downstream side of the flow of wet out-air OAw (that is, from the fuel cell 1 to the exhaust opening 14), there are provided a second shutoff valve 42, a pressure sensor 35, a humidifier 3 and a third shutoff valve 43 and a pressure adjusting valve 16 in the stated order.

The first reverse cleansing piping 31 is installed in such a way that one end is connected between the supercharger 2 and the first shutoff valve 41 so as to bypass the first shutoff valve 41 and the humidifier 3 in the air piping 7, and other end is connected between the humidifier 3 and the fuel cell 1, and a fourth shutoff valve 44 is provided with the first reverse cleansing piping 31.

The second reverse cleansing piping 32 is installed in such a way that one end is connected between the fuel cell 1 and the second shutoff valve 42 so as to bypass the second shutoff valve 42, the pressure sensor 35 and the humidifier 3 in the out-air piping 8, and other end is connected between the humidifier 3 and the third shutoff valve 43, and a fifth shutoff valve 45 is provided with the second reverse cleansing piping 32.

The first exhaust piping 33 is installed in such a way that one end is connected between the humidifier 3 and the first shutoff valve 41 in the air piping 7, and other end is connected to an exhaust opening 51, and a sixth shutoff valve 46 is provided with the first exhaust piping 33.

The second exhaust piping 34 is installed in such a way that one end is connected between the second shutoff valve 42 and the pressure sensor 35 so as to bypass the pressure sensor 35, the humidifier 3 and the third shutoff valve 43 in the out-air piping 8, and other end is connected between the third shutoff valve 43 and the pressure adjusting valve 16, and a seventh shutoff valve 47 is provided with the second exhaust piping 34.

During the normal mode of operation, the first, second and third shutoff valves 41, 42, 43, respectively, are opened, and the fourth, fifth, sixth and seventh shutoff valves 44, 45, 46, 47, respectively, are closed. The outside air (dry air Ad) inhaled

from the intake opening 11 by the supercharger 2 recovers moisture from the wet out-air OAw discharged from the fuel cell 1 in the humidifier 3 which straddles both air piping 7 and the out-air piping 8, to produce wet air Aw which is supplied to the fuel cell 1.

The wet air Aw is used for electrical generation together with the hydrogen supplied from a high pressure hydrogen tank (not shown) to the fuel cell 1 as well as for supplying moisture to maintain the solid polymer membrane in the fuel cell 1 in the water-saturated state.

The reverse flow cleansing mode of operation of the fuel cell humidifying system as an example of operation of the system will be explained with reference to Fig. 4.

The reverse flow cleansing mode of operation is carried out not only while the fuel cell 1 is stopped but also while the vehicle is moving. For example, when the fuel cell 1 is installed in an electric vehicle or a hybrid vehicle, this mode of operation is carried out while the vehicle is stopped or moving, if the pressure detected by the pressure sensor 35 at the inlet of the hollow thread membrane exceeds a preset value for each output pressure setting by 5 kPa.

In the following, the reverse flow cleansing mode of operation when the vehicle is electrically driven by using the power from the battery (not shown) will be explained as an example of the reverse flow cleansing mode of operation.

Prior to reverse flow cleansing, the system is prepared so that the first, second and third shutoff valves 41, 42, 43, respectively, are switched from "open" to "close", and the fourth, fifth, sixth and seventh shutoff valves 44, 45, 46, 47, respectively, are switched from "close" to "open".

From this condition, the dry air Ad inhaled the air piping 7 from the inlet opening 11 by the supercharger 2 flows into the first reverse cleansing piping 31, and after passing through the fourth shutoff valve 44, it is divided into dry air Ad1 to flow towards the humidifier 3 and dry air Ad2 to flow towards the fuel cell 1.

The dry air Ad1 flows into the humidifier 3 and traverses the dry air passage in the reverse direction, and after exiting from the humidifier 3, it is exhausted from the exhaust opening 51 through the sixth shutoff valve 46.

On the other hand, the dry air Ad2 passes through the fuel cell 1 and flows into the second reverse cleansing piping 32 from the out-air piping 8, and after passing through the fifth shutoff valve 45, it returns again to the out-air piping 8 and flows into the humidifier 3.

After this stage, the dry air Ad2 flows in the reverse direction through the wet out-air passage in the humidifier 3, and after exiting the humidifier 3, it passes through

the pressure sensor 35 and flows into the second exhaust piping 34, and further, after passing through the seventh shutoff valve 47, it returns again to the out-air piping 8 and exhausted from the exhaust opening 14 through the pressure adjusting valve 16.

As described above, according to this embodiment of the fuel cell humidifying system, while the vehicle is driven, the dry air Ad from the supercharger 2 is made to flow in the reverse direction in the dry air passage and the most out-air passage inside the humidifier 3 when the inlet pressure of the hollow thread membrane detected by the pressure sensor 35 exceeds a predetermined value, and therefore, it is possible to resolve the problem of clogging in the hollow thread membrane using the reverse flow cleansing.

Furthermore, the system is for cleansing the humidifier 3 by switching the flow direction of the air in the humidifier 3. That is, the system functions as a cleansing mechanism for preventing clogging in the humidifier 3.

It is noted that although the dry air Ad1 is made to flow in reverse not only in the wet out-air passage but also in the dry air passage in the humidifier 3, as far as the dry air passage is concerned, it is permissible to let the dry air Ad1 flow in the same direction as the direction of flow during the normal mode of operation. The reason is that, compared with the wet out-air OAw discharged from the fuel cell 1, the dry air Ad1 exiting from the supercharger 2 is filtered in the upstream side to remove dust particles and the like, resulting in relatively cleaner air so that it is unlikely to cause clogging so that there is less need for cleansing the dry air passage.

Another cleansing mechanism which is suitable for cleansing the humidifier 3 can be also provided in addition to the above-described system which performs reverse flow cleansing by switching the flow direction of the air. For example, a cleansing mechanism having a tank which enables to collect gas can be provided in the air piping. In this mechanism, the reverse flow cleansing and is performed in case of need, by opening the tank and releasing the gas into the piping when the switching of the flow direction of the air is performed.

Also, it is obvious that the cleansing mechanisms as disclosed above are effective in resolving clogging caused by freezing in the humidifier 3.

Third Embodiment

It is noted that, to prevent clogging in the dry air passage and the wet out-air passage in the humidifier 3 of the present fuel cell humidifying system having the water permeable type humidifier 3, it is effective to provide filters on each humidifier side of the air piping 7 and the out-air piping 8.

Fig. 5 shows a configuration of a third embodiment fuel cell humidifying system produced by adding the filters to the system described in the second embodiment. In the diagram, the reference numerals 61a, 61b relate to filters, and 62 relates to unreacted matter removal means comprised by an adsorbing agent such as activated charcoal and zeolite or platinum catalyst. Other components are the same as those in the fuel cell humidifying system described in the second embodiment and are given the same reference numerals.

As described above, when the filter 61a is provided between the fuel cell 1 and the humidifier 3 in the out-air piping 8, substances such as cell debris and rust particles contained in the wet out-air OAw exiting from the fuel cell 1 are captured by the filter 61a so that it is possible to prevent such substances to flow into the humidifier 3 so that clogging can be prevented before such clogging are developed.

Also, when the filter 61b is provided between the supercharger 2 and humidifier 3 in the air piping 7, it can work in conjunction with the filter provided with the supercharger 2 so that substances such as dust particles contained in the dry air Ad can be prevented reliably from entering into the humidifier 3, and clogging can be prevented even more effectively.

However, as operational times are accumulated on the system, the filters 61a, 61b can become clogged so that it is necessary to clean the filters by reverse flow cleansing periodically or according to the readings of the filter inlet pressure obtained by the pressure sensor 35. In such a case, clogging in the filters 61a, 61b can be cleared by conducting a similar process of reverse flow cleansing described in the second embodiment.

Also, in this embodiment, the unreacted matter removal means 62 comprised by adsorbing agent such as activated charcoal and zeolite or platinum catalyst is provided between the filter 61a and the humidifier 3 so that it is possible to prevent such substances contained in the wet out-air OAw from entering the humidifier 3 by eliminating them by adsorbing or combusting the unreacted matters. Therefore, it is possible to prevent difficulties which may arise when such unreacted matters from the fuel cell 1 passing through the hollow thread membrane in the humidifier 3, and the wet out-air OAw containing such matters is used to humidify the fuel cell 1 to cause degradation in the performance of the fuel cell 1.